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#17

Docket No. 224569US25SD
IN RE APPLICATION OF: Chen
SERIAL NO: 09/833,016
FILED: April 10, 2001
FOR: FORCE-BALANCE ROLLER CONE BITS, SYSTEMS, DRILLING METHODS, AND DESIGN METHODS

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COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313

SIR:
Transmitted herewith is an amendment in the above-identified application.

- [x] No additional fee is required
- [ ] Small entity status of this application under 37 C.F.R. §1.9 and §1.27 is claimed.
- [x] Additional documents filed herewith: 37 CFR 1.604 Request for an Interference with an Application

The Fee has been calculated as shown below:

CLAIMS	CLAIMS REMAINING		HIGHEST NUMBER PREVIOUSLY PAID	NO. EXTRA CLAIMS	RATE	CALCULATIONS
TOTAL	17	MINUS	33	0	x $18 =	$0.00
INDEPENDENT	9	MINUS	9	0	x $84 =	$0.00
		☐ MULTIPLE DEPENDENT CLAIMS			+ $280 =	$0.00
		TOTAL OF ABOVE CALCULATIONS				$0.00
		☐ Reduction by 50% for filing by Small Entity				$0.00
		☐ Recordation of Assignment			+ $40 =	$0.00
					TOTAL	$0.00

- [ ] A check in the amount of **$0.00** is attached.
- [ ] Credit card payment form is attached to cover the fees in the amount of **$0.00**
- [x] Please charge any additional Fees for the papers being filed herewith and for which no check or credit card payment form is enclosed herewith, or credit any overpayment to deposit Account No. 15-0030. A duplicate copy of this sheet is enclosed.
- [x] If these papers are not considered timely filed by the Patent and Trademark Office, then a petition is hereby made under 37 C.F.R. §1.136, and any additional fees required under 37 C.F.R. §1.136 for any necessary extension of time may be charged to Deposit Account No. 15-0030. A duplicate copy of this sheet is enclosed.

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#17

DOCKET NO: 224569US25SD

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF :

CHEN : EXAMINER: R. W. FREJD (ANTICIPATED)

SERIAL NO: 09/833,016 :

FILED: APRIL 10, 2001 : GROUP ART UNIT: 2123

FOR: FORCE-BALANCED ROLLER-CONE BITS, SYSTEMS, DRILLING METHODS, AND DESIGN METHODS :

37 CFR 1.604 REQUEST FOR AN
INTERFERENCE WITH AN APPLICATION

COMMISSIONER FOR PATENTS
ALEXANDRIA, VIRGINIA 22313
SIR:

I. 37 CFR 1.604(a)(1)

Applicant proposes the following count, which is in the format approved by the Commissioner in Orikasa v. Oonishi, 10 USPQ2d 1996, 2003 (Comm'r 1990), and Davis v. Uke, 27 USPQ2d 1180, 1188 (Comm'r 1993):

Claims 1, 5, 10, 16, 22, 23, 24, 25, and 26 of the party Huang's application serial No. 09/635,116

OR

Claims 34, 35, 36, 40, 46, 47, 48, 49, and 50 of the party Chen's application serial No. 09/833,016.

Claims 34-50 presented in the 37 CFR 1.604(a)(1) amendment submitted herewith correspond to the proposed count. Indeed, the proposed count includes all of the independent claims in that group of claims.

II. 37 CFR 1.604(a)(2)

The other application is application serial No. 09/635,116 filed August 09, 2000 and naming Huang et al. as inventors. If that application is now abandoned, this request is directed to any continuation of that application now pending.

Applicant believes that all claims in application serial No. 09/635,116 or any continuation of that application now pending correspond to the proposed count. Since applicant does not have access to that application, he cannot be sure. This request is based on the fact that the assignee of the Huang application has informed the assignee of the Chen application that the subject matter of Huang's claims 1-27 has been allowed in Huang's application. Applicant does not know the actual claim numbers used in the Huang application. The copy of Huang's claims provided to Chen's assignee by Huang's assignee were numbered 1-27.

III. 37 CFR 1.604(a)(3)

The interference should be declared because, as shown by the table below, the parties are claiming the same patentable invention.

Chen's Application	**Huang's Application**
34. A method for determining a volume of formation cut by each one of a plurality of roller cones on a drill bit drilling in earth formations, comprising:	5. A method for determining a volume of formation cut by each one of a plurality of roller cones on a drill bit drilling in earth formations, comprising:
selecting bit design parameters, comprising at least a geometry of a cutting element on the drill bit;	selection bit design parameters, comprising at least a geometry of a cutting element on the drill bit;
selecting at least one characteristic of an earth formation to be simulated as being drilled by the drill bit;	selecting at least one characteristic of an earth formation to be simulated as being drilled by the drilling bit;
simulating drilling of the earth	simulating drilling of the earth

formation, the simulating comprising calculating from the selected bit design parameters and the selected earth formation characteristic, parameters for a crater formed when each one of a plurality of cutting elements on each of the roller cones contacts the earth formation, the parameters including at least a volume of the crater;

simulating incrementally rotating the bit, and repeating the calculating of the crater parameters for a selected number of incremental rotations; and

combining the volume of each crater formed by each of the cutting elements on each of the roller cones to determine the volume of formation cut by each of the roller cones.

35. A method for balancing a volume of formation cut by each one of a plurality of roller cones on a drill bit drilling in earth formations, comprising:

selecting bit design parameters, comprising at least a geometry of a cutting element on the drill bit;

selecting at least one characteristic of an earth formation to be simulated as being drilled by the drill bit;

simulating drilling of the drill bit through the earth formation, the simulating comprising calculating from the selected bit design parameters and the selected earth formation characteristic, parameters for a crater formed when each one of a plurality of cutting elements on each of the roller cones contacts the earth formation, the parameters including at least a volume of the crater;

simulating incrementally rotating the bit, and repeating the calculating of the crater parameters for a selected number of simulated incremental rotations;

combining the volume of each crater

formation, the simulating comprising calculating from the selected bit design parameters and the selected earth formation characteristic, parameters for a crater formed when each one of a plurality of cutting elements on each of the roller cones contacts the earth formation, the parameters including at least a volume of the crater,

simulating incrementally rotating the bit, and repeating the calculating of the crater parameters for a selected number of incremental rotations; and

combining the volume of each crater formed by each of the cutting elements on each of the roller cones to determine the volume of formation cut by each of the roller cones.

16. A method for balancing a volume of formation cut by each of a plurality of roller cones on a drill bit drilling in earth formations, comprising:

selecting bit design parameters, comprising at least a geometry of a cutting element on the drill bit;

selecting at least one characteristic of an earth formation to be simulated as being drilled by the drill bit;

simulating drilling of the drill bit through the earth formation, the simulating comprising calculating from the selected bit design parameters and the selected earth formation characteristic, parameters for a crater formed when each one of a plurality of cutting elements on each of the roller cones contacts the earth formation, the parameters including at least a volume of the crater,

simulating incrementally rotating the bit, and repeating the calculating of the crater parameters for a selected number of simulated incremental rotations;

combining the volume of each crater

formed by each of the cutting elements on each of the roller cones to determine the volume of formation cut by each of the roller cones; and

adjusting at least one of the bit design parameters, and repeating the calculating the crater volume, incrementally rotating and combining the volume simulating until a difference between the combined volume cut by each of the cones is less than the combined volume determined prior to the adjusting the at least one of the bit design parameters.

formed by each of the cutting elements on each of the roller cones to determine the volume of formation cut by each of the roller cones; and

adjusting at least one of the bit design parameters, and repeating the simulating until a difference between the combined volume cut by each of the cones is less than the combined volume determined prior to the adjusting the at least one of the bit design parameters.

17. The method as defined in claim 16 wherein the volume of each of the craters is determined by:

determining an axial force on each of the cutting elements;

calculating, from the axial force on each of the cutting elements, an expected depth of penetration and projected area of contact between each of the cutting elements and the earth formation; and

calculating the volume of each of the craters from the expected depth of penetration and projected area of contact.

18. The method ad defined in claim 17 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

19. The method as defined in claim 18 wherein an incremental axial movement of the drill bit corresponding to the incrementally rotating is adjusted to cause the axial force on each of the cutting elements to total the axial force applied to the drill bit, the axial force acting on each of the cutting elements determined with respect to a predetermined relationship between depth of penetration and axial force applied for the cutting element geometry and the earth formation.

36. A method for determining an axial force acting on each one of a plurality of roller cones on a roller cone drill bit during drilling, comprising:

simulating drilling of an earth formation by the roller cone bit, the simulating comprising calculating, from a geometry of cutting elements on each of the roller cones and at least one characteristic of an earth formation being drilled by the drill bit, an axial force acting on each of the cutting elements;

simulating incrementally rotating the bit and recalculating the axial forces acting on each of the cutting elements;

repeating the simulating the incrementally rotating and recalculating for a selected number of incremental rotations; and

combining the axial force acting on the cutting elements on each one of the roller cones to determine the axial force acting on each of the roller cones.

37. The method as defined in claim 16 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

1. A method for determining an axial force acting on each one of a plurality of roller cones on a roller cone drill bit during drilling comprising:

simulating drilling of an earth formation by the roller cone bit, the simulating comprising calculating, from a geometry of cutting elements on each of the roller cones and at least one characteristic of an earth formation being drilled by the drill bit, an axial force acting on each of the cutting elements;

simulating incrementally rotating the bit and recalculating the axial forces acting on each of the cutting elements;

repeating the simulating the incrementally rotating and recalculating for a selected number of incremental rotations; and

combining the axial force acting on the cutting elements on each one of the roller cones to determine the axial force acting on each of the roller cones.

2. The method as defined in claim 1 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

3. The method as defined in claim 2 wherein an incremental axial movement of the drill bit corresponding to the incrementally rotating is adjusted to cause the axial force on each of the cutting elements to total the axial force applied to the drill bit, the axial force acting on each of the cutting elements determined with respect to a predetermined relationship between depth of penetration and axial force applied for the cutting element geometry and the earth formation.

4. The method as defined in claim 3 wherein the predetermined relationship is determined by laboratory experiment comprising impressing a cutting element

38. The method as defined in claim 17 wherein the volume of each of the craters is determined by:

determining an axial force on each of the cutting elements;

calculating, from the axial force on each of the cutting elements, an expected depth of penetration and projected area of contact between each of the cutting elements and the earth formation; and

calculating the volume of each of the craters from the expected depth of penetration and projected area of contact.

39. The method as defined in claim 18 further wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

having known geometry onto a selected earth formation, while measuring force on the cutting element and a corresponding depth of penetration of the cutting element into the selected earth formation.

6. The method as defined in claim 5 wherein the volume of each of the craters is determined by:

determining an axial force on each of the cutting elements;

calculating, from an axial force on each of the cutting elements, an expected depth of penetration and projected area of contact between each of the cutting elements and the earth formation; and

calculating the volume of each of the craters from the expected depth of penetration and projected area of contact.

7. The method as defined in claim 6 further wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

8. The method as defined in claim 7 wherein an incremental axial movement on the drill bit corresponding to the incrementally rotating is adjusted to cause the axial force on each of the cutting elements to total the axial force applied to the drill bit, the axial force acting on each of the cutting elements determined with respect to a predetermined relationship between depth of penetration and axial force applied for the cutting geometry and the earth formation.

9. The method as defined in claim 8 wherein the predetermined relationship is determined by laboratory experiment comprising impressing a cutting element having known geometry onto a selected earth formation, while measuring force on the cutting element and a corresponding depth of penetration of the cutting element into the selected earth formation.

40. A method for balancing axial forces acting on each one of a plurality of roller cones on a roller cone drill bit during drilling, comprising:

simulating the drill bit drilling through an earth formation, the simulating comprising calculating, from a geometry of cutting elements on each of the roller cones and at least one characteristic of an earth formation simulated as being drilled by the drill bit, an axial force acting on each of the cutting elements,

simulating incrementally rotating the bit and recalculating the axial forces acting on each of the cutting elements; repeating the incrementally rotating and recalculating for a selected number of simulated incremental rotations;

combining the axial force acting on the cutting elements on each one of the roller cones; and

adjusting at least one bit design parameter, and repeating the simulating until a difference between the combined axial force on each one of the roller cones is less than a difference between the combined axial force determined prior to adjusting the at least one initial design parameter.

41. The method as defined in claim 20 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

10. A method for balancing axial forces acting on each one of a plurality of roller cones on a roller cone drill bit during drilling, comprising:

simulating the rill bit drilling through an earth formation, the simulating comprising calculating, from a geometry of cutting elements on each of the roller cones and at least one characteristic of earth formation simulated as being drilled by the drill bit, an axial force acting on each of the cutting elements,

simulating incrementally rotating the bit and recalculating the axial forces acting on each of the cutting elements; repeating the incrementally rotating and recalculating for a selected number of simulated incremental rotations;

combining the axial forces on the cutting elements on each one of the roller cones; and

adjusting at least one bit design parameter, and repeating the simulating until a difference between the combined axial force on each one of the roller cones is less than a difference between the combined axial force determined prior to adjusting the at least one initial design parameter.

11. The method as defined in claim 10 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

12. The method as defined in claim 11 wherein an incremental axial movement of the drill bit corresponding to the incrementally rotating is adjusted to cause the axial force on each of the cutting elements to total the axial force applied to the drill bit, the axial force acting n each of the cutting elements determined with respect to a predetermined relationship between depth of penetration and axial force applied for the cutting element geometry and the

42. The method as defined in claim 20 wherein the at least one bit design parameter comprises a number of cutting elements on at least one of the cones.

43. The method as defined in claim 20 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.

44. The method as defined in claim 15 wherein the at least one bit design parameter comprises a number of cutting elements on at least one of the cones.

45. The method as defined in claim 15 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.

46. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit, the at least one design parameter comprising a parameter selected from the group of a number of cutting elements on each one of a plurality of roller cones, cutting element type, and a number of rows of cutting elements on each one of the plurality of roller cones;

repeating the simulating the bit drilling; and

earth formation.

13. The method as defined in claim 12 wherein the predetermined relationship is determined by laboratory experiment comprising impressing a cutting element having known geometry onto a selected earth formation, while measuring force on the cutting element and a corresponding depth of penetration of the cutting element into the selected earth formation.

14. The method as defined in claim 10 wherein the at least one bit design parameter comprises a number of cutting elements on at least one of the cones.

15. The method as defined in claim 10 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.

20. The method as defined in claim 16 wherein the at least one bit design parameter comprises a number of cutting elements on at least one of the cones.

21. The method as defined in claim 16 wherein the at least one bit design parameter comprise a location of cutting elements on at least one of the cones.

22. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit, the at least one design parameter comprising a parameter selected from the group of a number of cutting elements on each one of a plurality of roller cones, cutting element type, and a number of rows of cutting elements on each one of the plurality of roller cones;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until an optimized design is determined.

47. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until a rate of penetration of the bit through the selected earth formation is maximized.

48. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until an axial force on the bit is substantially balanced between the roller cones.

49. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until an optimized design is determined.

23. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until a rate of penetration of the bit through the selected earth formation is maximized.

24. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until an axial force on the bit is substantially balanced between the roller cones.

25. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until a volume of formation cut by the bit is substantially balanced between the roller cones.

50. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until an optimized design is determined, wherein the simulating comprises:

selecting bit design parameters;

selecting drilling parameters;

selecting an earth formation to be represented as drilled;

calculating from the selected parameters and the formation, parameters for a crater formed when one of a plurality of cutting elements on the bit contacts the earth formation, the cutting elements having known geometry;

calculating a bottomhole geometry, wherein the crater is removed from a bottomhole surface;

incrementally rotating the bit;

repeating the calculating of the crater parameters and the bottomhole geometry based on calculated roller cone rotation speed and geometrical location of the cutting elements with respect to rotation of the bit about its axis.

repeating the adjusting and simulating until a volume of formation cut by the bits is substantially balanced between the roller cones.

26. A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and simulating until an optimized design is determined, wherein the simulating comprises:

selecting bit design parameters;

selecting drilling parameters;

selecting an earth formation to be represented as drilled;

calculating from the selected parameters and the formation, parameters for a crater formed when one of a plurality of cutting elements on the bit contacts the earth formation, the cutting elements having known geometry;

calculating a bottomhole geometry, wherein the crater is removed from a bottomhole surface;

incrementally rotating the bit;

repeating the calculating of the crater parameters and the bottomhole geometry based on calculated roller cone rotation speed and geometrical location of the cutting elements with respect to rotation of the bit about its axis.

27. The method as defined in claim 26,

	wherein the calculated crater parameters are derived from laboratory tests comprising a cutting element having selected geometry be impressed on an earth formation sample with a selected force, the tests generating at least a correspondence between penetration depth of said cutting element into the formation and the selected force.

There are no differences between the party Chen's claims and the party Singh's claims listed side-by-side above. Thus, it is clear that the parties are claiming the same patentable invention.

Moreover, Chen submits that the subject matter defined by Singh's dependent claims 3, 4, 8, 9, 12, 13, and 16-19 would have been obvious to a person having ordinary skill in the art in the 1998-2000 time frame from the subject matter defined by their respective independent claims. Therefore, they should also be designated as corresponding to the proposed count.

IV. SUPPORT FOR COPIED CLAIMS

The application of the terms of claims 34-50 to the specification of the parent application is shown below:

Application Claims	**Support in the Specification**
34. A method for determining a volume of formation cut by each one of a plurality of roller cones on a drill bit drilling in earth formations, comprising:	Page 17 Line 3: "It is not difficult to calculate the volumes removed by each row .... Let V_1, V_2 and V_3 be the volume removed by cone 1, 2 and 3, respectively. ..." Page 11 Line 8: "Designer can **evaluate** the force balance and **energy balance** conditions of existing bit designs." Page 16 Line 12: "As we stated in previous sections, there are many **parameters** which affect bit balance conditions. Among these parameters, the **teeth crest length**, their positions on cones **(row distribution on**

cone) and the number of teeth play a significant role. An increase in the size of any one parameter must of necessity result in the decrease or increase of one or more of the others."

selecting bit design parameters, comprising at least a geometry of a cutting element on the drill bit;

Page 16 Line 20: "The first step in the optimization procedure is to choose the **design variables**. Consider a cone of a steel tooth bit as shown in Figure 3. The cone has three rows. For the sake of simplicity, the journal angle, the offset and the cone profile will be fixed and will not be as design variables. Therefore the only design variables for a row are the **crest length**, Lc, the **radial position** of the center of the crest length, Rc, and the **tooth angles**…. Therefore, the number of design variables is 4 times of the total number of rows on a bit."

Page 17 Line 15: "For example, V_{32} is the element in the volume matrix representing the rock volume removed by the second row of the third cone. The elements V_{ij} of this matrix are all functions of the design **variables**." Applicant submits that: "Design variables" and "design parameters" are synonymous.

selecting at least one characteristic of an earth formation to be simulated as being drilled by the drill bit;

Page 13 Line 13: "The force-cutting relationship for this single element may be described by:

$$F_{ze} = k_e * \sigma * S_e \qquad (1)$$

$$F_{xe} = \mu_x * F_{ze} \qquad (2)$$

$$F_{ye} = \mu_y * F_{ze} \qquad (3)$$

Where F_{ze} is the normal force and F_{xe}, F_{ye} are side forces, respectively, σ is the compressive strength, S_e the cutting depth and **k_e, μ_x and μ_y are coefficient associated with formation properties.**"

Page 7 Line 15: "More recently, computer programs have been developed which predict and simulate the bottom hole patterns developed by roller cone bits by combining the complex movement of the teeth with a **model of formation failure**. (Ma, … 1995)."

Page 13 Line 26: "There are many types of inserts used today for roller cone bit **depending on the rock type** drilled."

simulating drilling of the earth formation, the simulating comprising calculating from the selected bit design parameters and the selected earth formation characteristic, parameters for a crater formed when each one of a plurality of cutting elements on each of the roller cones contacts the earth formation, the parameters including at least a volume of the crater;

Page 20 line 1: "... the volume of formation removed by each tooth in each row, of each cutting structure (cone), is calculated. This calculation is based on input data of bit geometry, rock properties, and operational parameters."

Page 17 Line 20: "... the volume matrix calculated in a 2D manner must be scaled. The scale matrix, K_v, may be obtained as follows.

$K_v (i,j) = V_{3d0} (i,j) / V_{2d0} (i,j)$ (9)

where V_{3d0} is the volume matrix of the initial designed bit (before optimization). V_{3d0} is obtained from the rock bit computer program by **simulate** [simulating] the bit drilling procedure [for] at least 10 seconds."

Page 14 Line 21: "At any time t, the position of a tooth in space is fully determined. If the tooth is in interaction with the hole bottom, **the hole bottom is updated** and the cutting depth for each cutting element is calculated and the forces acting on the elements are obtained."

Page 27 line 8 *(Claim 10 as filed)*: "(d) calculating the volume of formation displaced by a **crater** enlargement parameter function."

simulating incrementally rotating the bit, and repeating the calculating of the crater parameters for a selected number of incremental rotations; and

Page 14 Line 10: "(1) The **bit kinematics** is described by bit rotation speed, Ω=RPM (revolutions per minute), and the rate of penetration, ROP. Both RPM and ROP may be considered as constant or as *[varying]* function with time.

(2) The **cone kinematics** is described by cone rotational speed. Each cone may have its own speed. The initial value is calculated from the bit geometric parameters or just estimated from experiment. In the calculation the cone speed may be changed based on the torque acting on the cone. ...

(5) After the bit is fully drilled into

the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is simulated."

Page 19 line 10: "Figure 6 shows the flowchart of the optimization procedure. The procedure begins by reading the bit geometry and other operational parameters. The forces on the teeth, cones, bearings, and bit are then calculated. Once the forces are known, they are compared, and if they are balanced, then the design is optimized. If the forces are not balanced, then the optimization must occur. Objectives, constraints, design variables and their bounds (maximum and minimum allowed values) are defined, and the variables are altered to conform to the new objectives. Once the new objectives are met, the new geometric parameters are used to re-design the bit, and the forces are again calculated and checked for balance. This process is repeated until the desired force balance is achieved."

combining the volume of each crater formed by each of the cutting elements on each of the roller cones to determine the volume of formation cut by each of the roller cones.

Page 21 Line 22: " (a) calculating the volume of formation cut by each tooth on each cutting structure; (b) calculating the volume of formation cut by each cutting structure per revolution of the drill bit; …."

Page 17 Line 8: "… the objective is to let each cone remove the same amount of rock in one bit revolution. This is called volume balance or energy balance. …
The volume matrix has the final form:
$V_b(I,j) = K_v(i,j) * V(i,j) = f_v (L_c, R_c, \alpha, \beta)$ (10)
Let V_1, V_2 and V_3 be the volume removed by cone 1,2 and 3, respectively. …"

Page 14 Line 6: "The element forces are integrated into tooth forces, the tooth forces are integrated into cone forces, the cone forces are transferred into bearing forces and the bearing forces are integrated into bit forces."

Although the passage at page 14 refers to summation of forces, the volumes are

	similarly summed to calculate the cone volumes V_1, V_2 and V_3.
35. A method for balancing a volume of formation cut by each one of a plurality of roller cones on a drill bit drilling in earth formations, comprising:	Page 10 Line 17: "The roller cone bit is energy balanced such that each of the cutting structures drill substantially equal volumes of formation."
selecting bit design parameters, comprising at least a geometry of a cutting element on the drill bit;	Passages at Page 16 Line 12, Page 16 Line 20 and Page 17 Line 15, as quoted above for Claim 34.
selecting at least one characteristic of an earth formation to be simulated as being drilled by the drill bit;	Passages at Page 13 Line 13, Page 7 Line 15, and Page 13 Line 26, as quoted above for Claim 34.
simulating drilling of the drill bit through the earth formation, the simulating comprising calculating from the selected bit design parameters and the selected earth formation characteristic, parameters for a crater formed when each one of a plurality of cutting elements on each of the roller cones contacts the earth formation, the parameters including at least a volume of the crater;	Passages at Page 17 Line 20, Page 14 Line 21, Page 20 Line 1, and Page 27 line 8, as quoted above for Claim 34.
simulating incrementally rotating the bit, and repeating the calculating of the crater parameters for a selected number of simulated incremental rotations;	Passage at Page 14 Line 10 and Page 19 line 10 as quoted above for Claim 34.
combining the volume of each crater formed by each of the cutting elements on each of the roller cones to determine the volume of formation cut by each of the roller cones; and	Passage at Page 21 line 21, Page 17 Line 8, and Page 14 line 6 as quoted above for Claim 34.
adjusting at least one of the bit design parameters, and repeating the calculating the crater volume, incrementally rotating and combining the volume simulating until a difference between the combined volume cut by each of the cones is less than difference in the combined volume determined prior to the adjusting the at least one of the bit design parameters.	Page 17 Line 2: "... the objective is to let each cone remove the same amount of rock in one bit revolution. This is called **volume balance** or energy balance." Page 18 Line 4: "Let V_1, V_2 and V_3 be the volume removed by cone 1,2 and 3, respectively. For the energy balance, the objective function takes the following form:

$Obj = (V_1-V_m)^2 + (V_2-V_m)^2 + (V_3-V_m)^2$
(11)
Where $V_m = (V_1 + V_2 + V_3)/3$"

Page 15 Line 9: "A bit is perfectly balanced if:
$\omega 1 = \omega 2 = \omega 3 = 33.333\%$ or $\omega 0 = 0.0\%$
$\eta 1 = \eta 2 = \eta 3 = 33.333\%$ or $\eta 0 = 0.0\%$
$\lambda 1 = \lambda 2 = \lambda 3 = 33.333\%$ or $\lambda 0 = 0.0\%$
$\xi = 0.0\%$
In most cases if $\omega 0$, $\eta 0$, $\lambda 0$, $\xi 0$ are **controlled with some limitations**, the bit is balanced. The values of $\omega 0$, $\eta 0$, $\lambda 0$, $\xi 0$ depend on bit size and bit type."

Page 19 Line 15: "If the forces are not balanced, then the optimization must occur. Objectives, constraints, design variables and their bounds (maximum and minimum allowed values) are defined, and the variables are altered to conform to the new objectives. Once the new objectives are met, the new geometric parameters are used to re-design the bit, and the forces are again calculated and checked for balance."

Page 21 Line 26: "(c) comparing the volume of formation cut by each of said cutting structures with the volume of formation cut by all others of said cutting structures of the bit; (d) adjusting at least one geometric parameter on the design of at least one cutting structure; and (e) repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit.

Page 10 Line 17: "The roller cone bit is energy balanced such that each of the cutting structures drill substantially equal volumes of formation."

The specification discloses both force balancing and volume balancing as possible objectives. The description of Figure 6 specifically refers to the force balancing objective, but volume balancing is also very specifically disclosed as another possible objective.

36. A method for determining an axial force acting on each one of a plurality of roller cones on a roller cone drill bit during drilling, comprising:	Page 19 Line 11: "The procedure begins by reading the bit geometry and other operational parameters. The forces on the teeth, cones, bearings, and bit are then calculated."
simulating drilling of an earth formation by the roller cone bit, the simulating comprising calculating, from a geometry of cutting elements on each of the roller cones and at least one characteristic of an earth formation being drilled by the drill bit, an axial force acting on each of the cutting elements;	Page 14 Line 19: "At the initial time, t0, the hole bottom is considered as a plane and is meshed into small grids. The tooth is also meshed into grids (single elements). At any time t, the position of a tooth in space is fully determined. If the tooth is in interaction with the hole bottom, the hole bottom is updated and the cutting depth for each cutting element is calculated and **the forces acting on the elements are obtained**." Page 22 Line 3: "(a) calculating the axial force acting on each tooth on each cutting structure; (b) calculating the axial force acting on each cutting structure per revolution of the drill bit;...."
simulating incrementally rotating the bit and recalculating the axial forces acting on each of the cutting elements;	Page 14 Line 29: "(5) After the bit is fully drilled into the rock, **these forces are recorded at each time step.** A period [of] time [of] usually at least 10 seconds is simulated."
repeating the simulating the incrementally rotating and recalculating for a selected number of incremental rotations; and	
combining the axial force acting on the cutting elements on each one of the roller cones to determine the axial force acting on each of the roller cones.	Page 14 Line 26: "The element forces are integrated into tooth forces, **the tooth forces are integrated into cone forces**, the cone forces are transferred into bearing forces and the bearing forces are integrated into bit forces."
37. The method as defined in claim 16 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.	Page 14 Line 26: "The element forces are integrated into tooth forces, the tooth forces are integrated into cone forces, the cone forces are transferred into bearing forces and

the bearing forces are integrated into bit forces."

Page 8 Line 24: "The present application teaches that roller cone bit designs should have equal mechanical downforce on each of the cones. This is not trivial: without special design consideration, the weight on bit will NOT automatically be equalized among the cones."

38. The method as defined in claim 17 wherein the volume of each of the craters is determined by:

determining an axial force on each of the cutting elements;

Passage at Page 14 line 26: as quoted above.

calculating, from the axial force on each of the cutting elements, an expected depth of penetration and projected area of contact between each of the cutting elements and the earth formation; and

Page 14 line 21: "At any time t, the position of a tooth in space is fully determined. If the tooth is in interaction with the hole bottom, the hole bottom is updated and the cutting depth for each cutting element is calculated and the forces acting on the elements are obtained."

calculating the volume of each of the craters from the expected depth of penetration and projected area of contact.

Page 17 line 10: "Suppose the bit has a cutting depth Δ in one bit revolution. It is not difficult to calculate the volumes removed by each row and the volume matrix may have the form:

$$V = [\ V_{ij}\ ],\quad I=1,2,3;\ j=1,2,3,4,... \qquad (8)$$

where i represent the cone number and j the row number."

39. The method as defined in claim 18 further wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

Page 13 lines 6: "The present invention uses a single element force-cutting relationship in order to develop the total force-cutting relationship of a cone and of an entire roller cone bit."

40. A method for balancing axial forces acting on each one of a plurality of roller cones on a roller cone drill bit during drilling, comprising:

Page 8 Line 24: "The present application teaches that roller cone bit designs should have equal mechanical downforce on each of the cones. This is not trivial: without special design consideration, the weight on bit will NOT automatically be equalized

among the cones."

Page 10 Line 15: "The roller cone bit is **force balanced** such that axial loading between the arms is substantially equal."

simulating the drill bit drilling through an earth formation, the simulating comprising calculating, from a geometry of cutting elements on each of the roller cones and at least one characteristic of an earth formation simulated as being drilled by the drill bit, an axial force acting on each of the cutting elements,

Page 19 lines 12: "The forces on the teeth, cones, bearings, and bit are then calculated."

Page 22 Line 3: "(a) calculating the axial force acting on each tooth on each cutting structure; (b) calculating the axial force acting on each cutting structure per revolution of the drill bit; (c) comparing the axial force acting on each of said cutting structures with the axial force on the other ones of said cutting structures of the bit …."

simulating incrementally rotating the bit and recalculating the axial forces acting on each of the cutting elements; repeating the incrementally rotating and recalculating for a selected number of simulated incremental rotations;

combining the axial force acting on the cutting elements on each one of the roller cones; and

adjusting at least one bit design parameter, and repeating the simulating until a difference between the combined axial force on each one of the roller cones is less than a difference between the combined axial force determined prior to adjusting the at least one initial design parameter.

Page 22 line 7: "(d) **adjusting at least one geometric parameter** on the design of at least one cutting structure; (e) repeating steps (a) through (d) until approximately the same axial force is acting on each cutting structure."

Page 19 Line 13: "Once the forces are known, they are compared, and if they are balanced, then the design is optimized. If the forces are not balanced, then the optimization must occur. Objectives, constraints, design variables and their bounds (maximum and minimum allowed values) are defined, and the variables are altered to conform to the new objectives. Once the new objectives are met, **the new geometric parameters are used to re-design the bit**, and the forces are again calculated and checked for balance. This process is repeated until the desired force balance is achieved."

Page 15 Line 9: "…the balance condition of a roller cone bit may be evaluated using the following criteria:

$$\text{Max}(\omega 1,\omega 2,\omega 3) - \text{Min}(\omega 1,\omega 2,\omega 3) \le \omega 0$$

… where ωi (i=1,2,3) is defined by $\omega i = WOBi / WOB * 100\ \%$, WOBi is the weight on bit taken by cone i.

… A bit is perfectly balanced if:

$\omega 1 = \omega 2 = \omega 3 = 33.333\ \%$ or $\omega 0 = 0.0\ \%$

… In most cases if $\omega 0$, $\eta 0$, $\lambda 0$, $\xi 0$ are controlled **with some limitations**, the bit is balanced. The values of $\omega 0$, $\eta 0$, $\lambda 0$, $\xi 0$ depend on bit size and bit type."

41. The method as defined in claim 20 wherein the axial force acting on each of the cutting elements totals an axial force applied to the drill bit.

Page 15 Line 16: "ωi (i=1,2,3) is defined by $\omega i = WOBi / WOB * 100\ \%$, WOBi is the weight on bit taken by cone i….

A bit is perfectly balanced if: $\omega 1 = \omega 2 = \omega 3 = 33.333\ \%$ …."

42. The method as defined in claim 20 wherein the at least one bit design parameter comprises a number of cutting elements on at least one of the cones.

Page 16 Line 15. "Among these parameters, the teeth crest length, their positions on cones (**row distribution on cone**) and the **number of teeth** play a significant role."

43. The method as defined in claim 20 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.

Page 16 Line 15. "Among these parameters, the teeth crest length, their positions on cones (**row distribution on cone**) and the **number of teeth** play a significant role."

44. The method as defined in claim 15 wherein the at least one bit design parameter comprises a number of cutting elements on at least one of the cones.

Page 16 Line 15. "Among these parameters, the teeth crest length, their positions on cones (**row distribution on cone**) and the **number of teeth** play a significant role."

45. The method as defined in claim 15 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.

Page 16 Line 15. "Among these parameters, the teeth crest length, their positions on cones (**row distribution on cone**) and the **number of teeth** play a significant role."

46. A method for optimizing a design of a roller cone drill bit, comprising:

Page 1 line 8: "The present invention relates to down-hole drilling, and especially to the optimization of drill bit parameters."

Page 9 Line 24: "The present application describes bit design procedures which provide optimization of downforce balancing as well as other parameters."

simulating the bit drilling through a selected earth formation;	Page 14 line 29: "After the bit is fully drilled into the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is **simulated**. Page 17 Line 26: "V3d0 is obtained from the rock bit computer program by simulate [simulating] the bit drilling procedure [for] at least 10 seconds."
adjusting at least one design parameter of the bit, the at least one design parameter comprising a parameter selected from the group of a number of cutting elements on each one of a plurality of roller cones, cutting element type, and a number of rows of cutting elements on each one of the plurality of roller cones;	Page 22 Line 3: "(a) calculating the axial force acting on each tooth on each cutting structure; (b) calculating the axial force acting on each cutting structure per revolution of the drill bit; (c) comparing the axial force acting on each of said cutting structures with the axial force on the other ones of said cutting structures of the bit; (d) **adjusting at least one geometric parameter on the design** of at least one cutting structure…." Page 16 line 12: "As we stated in previous sections, there are many parameters which affect bit balance conditions. Among these parameters, the teeth crest length, their positions on cones (row distribution on cone) and the number of teeth play a significant role."
repeating the simulating the bit drilling; and repeating the adjusting and simulating until an optimized design is determined.	Page 22 line 13: " (a) calculating the force balance conditions of a bit; (b) defining design variables; (c) determine lower and upper bounds for the design variables; (d) defining objective functions; (e) defining constraint functions; (f) performing an **optimization means**; and, (g) evaluating an optimized cutting structure by modeling. Page 21 Line 26: "(e) repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit." Page 22 Line 7: ". (e) repeating steps (a) through (d) until approximately the same axial force is acting on each cutting structure."

47. A method for optimizing a design of a roller cone drill bit, comprising:	Page 1 Line 8: "The present invention relates to down-hole drilling, and especially to the **optimization** of drill bit parameters." Page 9 Line 24: "The present application describes bit design procedures which provide **optimization** of downforce balancing as well as other parameters."
simulating the bit drilling through a selected earth formation;	Passage at Page 14 line 29 and Page 17 line 26 as quoted for claim 46.
adjusting at least one design parameter of the bit;	Passage at Page 22 line 3 and Page 16 line 12 as quoted for claim 46.
repeating the simulating the bit drilling; and	Passage at Page 22 line 13, Page 21 line 26, and Page 22 line 7 as quoted for claim 46.
repeating the adjusting and simulating until a rate of penetration of the bit through the selected earth formation is maximized.	Page 9 Line 21: "Equalized downforce is believed to be a significant factor in reducing gyration, and has been demonstrated to provide substantial improvement in **drilling efficiency**." Page 6 Line 10: "The economics of drilling a well are strongly reliant on **rate of penetration**. Since the design of the cutting structure of a drill bit controls the bit's ability to achieve a **high rate of penetration,** cutting structure design plays a significant role in the overall economics of drilling a well."
48. A method for optimizing a design of a roller cone drill bit, comprising:	Passage at Page 1 line 8 and Page 9 line 24 as quoted above for claim 46.
simulating the bit drilling through a selected earth formation;	Passage at Page 14 line 29 and Page 17 line 26 as quoted above for claim 46.
adjusting at least one design parameter of the bit;	Passage at Page 22 line 3 and Page 16 line 12 as quoted above for claim 46.
repeating the simulating the bit drilling; and repeating the adjusting and simulating until an axial force on the bit is substantially balanced between the roller cones.	Page 22 Line 9: "(e) repeating steps (a) through (d) until approximately the same axial force is acting on each cutting structure."
49. A method for optimizing a design of a roller cone drill bit, comprising:	Passages at Page 1 Line 8 and Page 9 Line 24 as quoted above for Claim 46.

simulating the bit drilling through a selected earth formation;	Passages at Page 14 Line 29 and Page 17 Line 26 as quoted for Claim 46.
adjusting at least one design parameter of the bit;	Passages at Page 22 Line 3 and Page 16 Line 12 as quoted for Claim 46.
repeating the simulating the bit drilling; and repeating the adjusting and simulating until a volume of formation cut by the bit is substantially balanced between the roller cones.	Page 21 Line 27: "repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit."
50. A method for optimizing a design of a roller cone drill bit, comprising:	Passages at Page 1 Line 8 and Page 9 Line 24 as quoted above for Claim 46.
simulating the bit drilling through a selected earth formation;	Passages at Page 14 Line 29 and Page 17 Line 26 as quoted for Claim 46.
adjusting at least one design parameter of the bit;	Passages at Page 22 Line 3 and Page 16 Line 12 as quoted for Claim 46.
repeating the simulating the bit drilling; and repeating the adjusting and simulating until an optimized design is determined, wherein the simulating comprises:	Passages at Page 22 Line 13, Page 21 Line 26, and Page 22 Line 7 as quoted above for Claim 46.
selecting bit design parameters;	Passages at Page 16 Line 12, Page 16 Line 20, and Page 17 Line 15 as quoted above for Claim 34.
selecting drilling parameters;	Page 19 Line 11: "The procedure begins by reading the bit geometry and other **operational parameters**." Page 20 Line 3: "This calculation is based on input data of bit geometry, rock properties, and **operational parameters**." Page 14 Line 10: "The bit kinematics is described by bit rotation speed, Ω=RPM (revolutions per minute), and the rate of penetration, ROP. Both RPM and ROP may be considered as constant or as *[varying]* function with time."

selecting an earth formation to be represented as drilled;	Passages at Page 13 Line 13, Page 7 Line 15, and Page 13 Line 26 as quoted above for Claim 34.
calculating from the selected parameters and the formation, parameters for a crater formed when one of a plurality of cutting elements on the bit contacts the earth formation, the cutting elements having known geometry;	Passages at Page 20 Line 1 and Page 17 Line 20 as quoted above for Claim 34.
calculating a bottomhole geometry, wherein the crater is removed from a bottomhole surface;	Page 14 Line 22: "If the tooth is in interaction with the hole bottom, **the hole bottom is updated....**" Page 27 line 8 (Claim 10 as filed): "(d) calculating the volume of formation displaced by a **crater** enlargement parameter function." Page 11 Line 10: "Designer can design force balanced drill bits with predictable **bottom hole patterns** without relying on lab tests followed by design modifications." Page 12 Line 11: "Figure 4 shows the **bottom hole pattern** generated by a steel tooth bit." Page 12 Line 19: "Figures 8A-B compare the bottom hole pattern before and after optimization."
incrementally rotating the bit;	Passages at Page 14 Line 10 and Page 19 Line 10 as quoted above for Claim 34.
repeating the calculating of the crater parameters and the bottomhole geometry based on calculated roller cone rotation speed and geometrical location of the cutting elements with respect to rotation of the bit about its axis.	Page 19 Line 15: "If the forces are not balanced, then the optimization must occur. Objectives, constraints, design variables and their bounds (maximum and minimum allowed values) are defined, and the variables are altered to conform to the new objectives. Once the new objectives are met, the new geometric parameters are used to re-design the bit, and the forces are again calculated and checked for balance. This process is repeated until the desired force balance is achieved. As an example, **Figures 7A-C** show

the row distributions on three cones of a 9" steel tooth bit before and after optimization. **Figures 8A** and **8B** compare the bottom hole patterns cut by the different cones before and after optimization. **Figures 9A** and **B** compare the cone layouts before and after optimization."

V. REQUEST FOR THE BENEFIT OF THE FILING DATES OF APPLICANT'S PRIORITY APPLICATIONS

Applicant claims priority under 35 USC 120 based upon application serial No. application serial No. 09/387,737 filed August 31, 1999. The present application is a straight continuation of the '737 application. Therefore, the application of the terms of claims 34-50 to the specification of the present application Section IV above applies to the '737 applications as well.

The August 31, 1999 filing date of the '737 application precedes the August 09, 2000 filing date of Huang's application serial No. 09/635,116. Therefore, Chen would be the senior party in the interference.

Applicant further claims priority under 35 USC 119(e) based on provisional application No. 60/098,466 filed August 31, 1998.

Applicant is entitled to the benefit of the filing dates of his earlier filed applications for interference purposes if the count reads on at least one adequately disclosed embodiment in the earlier application.[1] Assuming that the examiner recommends to the board applicant's proposed count, applicant clearly meets that standard.

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[1]Weil v. Fritz, 572 F.2d 856, 865-66 n.16, 196 USPQ 600, 608 n.16 (CCPA 1978).

Respectfully submitted,

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